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RESEARCH ARTICLE

Observations on the behavior of the saker falcon (*Falco cherrug*) breeding in Bulgaria

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Abstract

Saker falcon populations suffered severe declines, especially in the second half of the 20th century. During the period between 2004 and 2018, the species became extinct in Bulgaria as a breeding species. After that, a reintroduction program was implemented with birds originating from central Europe. We studied the main behavioral characteristics of both wild sakers from the local population of the species in SE-Bulgaria and these of the reintroduced birds which started breeding in the same region in a wild in 2018. We collected numerous observations on the territorial, hunting, and breeding (parental) behavior of that species. Territorial attacks against 16 bird species were recorded with prevailing numbers against kestrel (*Falco tinnunculus*) and imperial eagle (*Aquila heliaca*). The main hunting strategies of the species included attacks against sousliks (*Spermophilus citellus*) in their numerous colonies in the study area. Various species of birds were also captured and brought in the nest. Adults were feeding the nestlings in 31.5–55.3 min intervals depending on their age. In the morning hours (7 am – 12 pm) the duration of the feeding of the nestlings is lower – 11.35±3,5 min on average, compared to the afternoon (12 pm – 5 pm) – 18.81±6,81 min. After the disappearance of a female in 2021, the male alone fed and cared for three nestlings during a period of 19 days. The male stopped feeding the nestlings after finding another female and consequently all the nestlings were found dead.

Keywords
breeding season, ethology, falcons, feeding, hunting effort, nestlings, territoriality, reintroduction.

Introduction

Investigations on animal behavior recently have expanded and have emerged into a truly interdisciplinary science, encompassing such fields as behavior, physiology, pathology, health, immunology, endocrinology, and neuroscience (Marchant-Forde 2015). Ethological studies are difficult, take long time for observations demanding in many cases great patience by the researchers. The results of these studies typically have not only fundamental but also practical significance in nature conservation (Curio 1996; Svaisgood and Greggor 2019). Knowledge about details of animal behavior has key significance also for the understanding of evolutionary processes (McLennan 1991).

Behavior of birds of prey has been investigated in a number of long-term specific studies, focused usually on one particular species or group of closely related species such as falcons (Horvath 1975; Newton 1979; Bijsma 1980; Ellis et al. 1999; Leonardi 2015). Attention to that group of birds is heightened because of their vulnerability, targeting by illegal human activities, and worldwide population decrease.

Saker falcon (saker) (*Falco cherrug*) is a medium-sized diurnal raptor distributed patchily in great parts of Eastern Europe and Asia (Cramp and Simmons 1980). The most numerous populations are still present in Mongolia, Kazakhstan, China, Hungary, Slovakia, Ukraine, and some parts of Southern Russia (Dixon 2009; Keller et al. 2020). The majority of saker populations suffered severe declines, especially in the second half of the 20th century (Ferguson-Lees and Christie 2001; Ragyov et al. 2014). Thus, the species is globally threatened – categorized as "Endangered" in IUCN Red List (Birdlife International 2022).

By the end of the 19th century, saker falcon had been common and numerous breeding species in Bulgaria (Reiser 1894; Pateff 1950). A strong decrease in the numbers and breeding distribution was reported during the 1960s (Stoyanov and Kouzmanov 1998; Iankov 2007). Most of the population moved from the lowlands to the mountains (Baumgart 1977). Until 1990 the breeding population was more or less stable at a level of 30 – 50 pairs (Simeonov et al. 1990; Nankinov et al. 1991).

In 1997 one of the last cases of successfully fledged nestlings was reported (Stoyanov 2001). During the period between 2004 and 2018, the species became extinct in Bulgaria as a breeding species. Nest robbery by poachers was reported as one of the main reasons for this process. Other possible factors were habitat destruction, a decrease in the abundance of the animal species used as main food sources, electrocution, killing by pigeon keepers, disturbance, and poisoning (Iankov et al. 2013).

Reproduction parameters and behavior of the saker are poorly known and not studied in Bulgaria (Simeonov et al. 1990; Iankov et al. 2013). Saker is among the

less studied falcons in the Palearctic in regard to its behavior (Cramp and Simmons 1980; Leonardi 2018). Worldwide, there are very few publications devoted to the behavior of the saker (Becsy 1978; Ellis et al. 1999; Bagyura et al. 2004). Data on kleptoparasitism is mentioned in the works of Braun and Lederer (1996), Shukurov and Davletbakov (2001), and Danko and Mihok (2007). The species is better studied in regard to its breeding biology, food spectrum, and population numbers, especially in Central Europe (Bagyura et al.2004; Puzovic 2008; Chavko et al.2014; Skorpikova et al. 2017; Chavko et al. 2019)

In this work, we describe some aspects of the behavior of saker, a threatened species, difficult to study and observe. Some of the studied birds were reintroduced during a conservation project (Dixon et al. 2020; Lazarova et al. 2021).

Material and methods

The study was conducted in the period 1998–2021. The behavior of three pairs of saker falcons was studied in SE-Bulgaria. One of the pairs was reintroduced. Both birds of the pair had been released as part of the saker reintroduction project of the NGO Green Balkans - Stara Zagora. A third bird released during the same program replaced the first female in 2020. The behavior was investigated during 210 hrs. of observations and is the object of the present study. In 2021 the female was found injured (probably by electrocution) during the nestling phase of the breeding period and sent for treatment to the "Green Balkans" Rehabilitation and Breeding Centre.

Data, mainly on the territorial behavior of the saker, was gathered from two other pairs monitored during the period 1998–2004. They were defending their territories and hunting in the rocky areas of Sliven Mountain, SE-Bulgaria. Their nests were not found. The observations were made in their wide hunting ranges, which included mountain foothills.

Observations on the saker behavior during the present study were made using ad libitum sampling - a descriptive method (Altman 1974; Lehner 1996). It includes rare but significant events. In other studies using of cameras installed at the nest give an opportunity for quantitative evaluations and the use of focal and scan sampling (Chavko et al. 2014). Movements of the nestlings after leaving the nest were followed using satellite telemetry (Gamauf, Dosedel 2012; Nemcek et al. 2014).

Food items brought to the nest were seen from a 250–400 m distance using a telescope 20–60X. That distance was chosen to minimize the disturbance to the nesting pair.

Study area

The couple of reintroduced sakers nested in a lowland area with many arable lands, orchards, and some pastures. Low hills and mountain slopes are situated in a close neighborhood. They are covered by natural grasslands (pastures) and bushes. In and

close to the nesting territory of the reintroduced sakers there were three breeding pairs of imperial eagles (*Aquila heliaca*), and the closest of them had its nest 2.4 km from the nest of the sakers; a pair of long-legged buzzards (*Buteo rufinus*) was breeding at a distance of 1.5 km; a hobby pair (*Falco subbuteo*) – at 3.2 km; two pairs of kestrels (*Falco tinnunculus*) – at 250 m and 850 m, a pair of ravens (*Corvus corax*) – at 670 m.

In the vicinity of the nest, there were a number of souslik (*Spermophilus citellus*) colonies and pastures with bush habitats inhabited by wild hares (*Lepus europaeus*), colonies of Spanish sparrows (*Passer hispaniolensis*), and nests of many other passerines.

The others saker pairs were observed in Slivenska Mt. and its foothills. The mountain is part of the main mountain range on the Balkan Peninsula – Stara Planina Mt. It is covered by beech and oak forests, large rocky areas, and bushes (in the low parts) (Bondev 1991). The highest peak reaches 1181 m asl. In the past, the sakers here traditionally nested on rocks.

Results

On 2/11/2017 a pair of sakers was observed in an abandoned nest (used previously by long-legged buzzard and raven) on an electricity pylon. Both birds of the pair had been ringed and released as part of the saker falcon reintroduction project of the Green Balkans - Stara Zagora NGO. This allowed their identification as the first reintroduced pair of sakers breeding in the wild on Bulgarian territory. Both birds were preparing the nest for the following season. The sakers nested successfully for three breeding seasons – 2018, 2019, and 2020 in the same location.

Territorial behavior

After establishing their territory by displaying flights and vocalizations between late February and early March, the sakers defend it until the end of the breeding period – between late July and early August.

Despite the fact that the species is territorial during the breeding period, there were few conflicts with other diurnal birds of prey.

For the reintroduced pair the most common were the conflicts with the neighboring two pairs of kestrels. Aggressive behavior (attacks) was observed from both sides. The kestrel attacks were mild, not as aggressive as against many other birds of prey. The kestrels attacked from a distance, without lowering the legs, usually with the participation of both partners of the pair. The attacks took place far from the nests, high in the sky. In these cases, the attacks ended when one of the sakers took a height above the kestrels and turned for a counterattack. The attack duration was 3 to 4 min and was rarely repeated within the same day. Such mock attacks were observed in 9 cases.

We recorded only two real attacks of the sakers against the kestrels. In these cases, the saker chased the closely passing kestrel for a distance of 300–400 m.

On three occasions the male saker landed on the pylon with the closest occupied nest of the kestrels. In two of these cases, the female kestrel was incubating. The male kestrel did not attack the saker and the female stayed low in her nest.

During all three years of observation, the pair of kestrels did not rear even one flying offspring, despite the successful hatching of the eggs. The chicks were fed normally. It can be assumed that the young kestrels were captured and eaten by the sakers.

Both partners of the saker pair took part in the nest defense. During the period of incubation, this task was performed only by the male. Attacks of sakers on other birds that entered their territory are summarized in Table 1.

When an imperial eagle approached the saker's nest at a distance of 700–800 m, one of the sakers took off and started circling demonstratively around the nest marking its presence with vocalizations. A direct attack against the Imperial Eagles was not observed. In one case a young imperial eagle continued its flight directly across the saker's territory and was escorted by the female saker. However, a real attack did not happen. The female flew higher up and succeeded in forcing the eagle to change the direction. A similar territorial flight of one of the sakers was observed also against a booted eagle (*Hieraaetus pennatus*).

Table 1. Cases of aggressive territorial behavior of adult sakers during the breeding period (February –August). Cases of kleptoparasitism are not included.

Attacked species	Saker pairs from Slivenska Mt.	Reintroduced pair	Total
Aquila heliacal	9	1	10
Aquila chrysaetos	2		2
Aquila nipalensis	1		1
Clanga pomarina	2	1	3
Hieraeetus pennatus		1	1
Accipiter nisus	1		1
Buteo buteo	2		2
Buteo rufinus	8		8
Circus aeruginosus	2	1	3
Circus cyaneus	2		2
Circus pygargus	1		1
Falco tinnunculus	11	18	29
Falco peregrinus	3		3
Falco Subbuteo	1	1	2
Corvus corax	3		3
Corvus corone cornix	3		3
Total	51	23	74

Real attacks with legs down and physical contact against larger raptors were observed only in two cases – against a lesser spotted eagle *(Clanga pomarina),* passing close to the saker's nest and against a marsh harrier (*Circus aeruginosus*). The lesser spotted eagle left the territory immediately after the first attack, but the marsh harrier was attacked four times before it changed direction northwards. Both attacks were performed by the female saker.

A group of five Eleonora's falcons (*Falco eleonorae)* hunting insects passed through the saker's territory. The male saker took off and landed on the top of another electric pylon. It stayed there and vocalized from time to time until the Eleonora's falcons went away.

Hobbies were chased by the sakers only in cases when they landed in the close vicinity of the nest.

Territorial conflicts with other sakers were not observed but it should be taken into account that the species is very rare in Bulgaria, even outside of the breeding season.

In three cases sakers observed in Slivenska Mt. during the breeding period attacked peregrine falcons (*Falco peregrinus*). These attacks were real, including physical contact and chasing.

Reverse attacks by peregrine (1 case), goshawk *(Accipiter gentilis*) (1 case), ravens (*Corvus corax*) (4 cases), hen harrier (*Circus cyaneus*) (1 case), long-legged buzzard (*Buteo rufinus*) (1 case) and kestrels (many cases) on sakers were also recorded. Mobbing by crag martins (*Ptyonoprogne rupestris*) on the saker was recorded in several cases.

As can be seen from Table 1, sakers from the mountains showed aggressive behavior more often compared to the reintroduced birds. Reintroduced sakers showed rarely aggressive behavior even against species such as *Aquila heliaca* and *Buteo rufinus* that were breeding at a very close distance to their nest.

Feeding behavior

The female saker was not hunting only when the nestlings were very small, less than 10 days old. This was probably due to the nestling thermoregulation not yet functioning fully. After the nestlings reached 10 days of age the female started hunting intensively.

While one of the partners was hunting, the other one guarded the nestlings. In the first three weeks, the male stayed for the night at or very close to the nest, after that at an observation point (pylon, tree) at a distance of 200–300 m from the nest.

The sakers carried the prey into the nest with their feet. On the edge of the nest, the adult saker stood on the prey, teared off pieces, and gave them to the nestlings beak to beak. When the nestlings were 15–20 days old the adult offered the piece with a bent head and waited until the nestling took it. After that period the adults gave the food with their heads up and nestlings could reach it.

The nestlings at an age of 20–45 days can feed on their own when the parents leave the prey in the nest, but beak-to-beak feeding also continued.

During the first 5–7 days after leaving the nest, the young sakers fed mostly on the ground. They collected invertebrates or small vertebrates (rodents), sometimes running a few steps on the ground. The adults continued to feed the fledglings by leaving them prey on the ground or giving it directly beak to beak, often when they were back in the nest.

The feeding frequency of the nestlings and the duration of the feeding event generally depended on the size of the prey and the age of the nestlings (Table 2).

During the first period, when the nestlings were 10–20 days old, the intensity of feeding is highest (Table 2), and the duration of separate feeding events was moderate. During this period the nestlings were fed with the smallest prey items (voles, mice, and passerines).

During the second period (nestlings aged 20–30 days) the frequency of feeding decreased. The prey items were mainly sousliks and other small mammals. The duration of the feeding events decreased compared to the first period. Often the partners of the pair met in the nest, both of them bringing food.

During the third period (nestlings aged 30–40 days) feeding items were much larger, including bigger birds (pigeons), in some cases even small wild hares. In the middle of that period, feeding became less frequent which can be a stimulus for the nestlings to leave the nest. The duration of the feeding events increased as the prey items were much larger.

The significant differences in the studied parameters for the three studied age classes of nestlings were as follows:

Duration of feeding event: 10–20 day vs 20–30 day – T test, $P<0.05$; 20–30 day vs 30–40 day - T test, $P<0.05$.

Frequency of feeding (interval of bringing food in the nest): 10–20 day vs 20–30 day - T test, $P<0.001$; 20–30 day vs 30–40 day -T test, $P<0.05$.

The differences between 10–20 day and 30–40 day period were not significant for both parameters.

In the morning hours (7 am – 12 pm) the duration of the feeding of the nestlings was on average lower - 11.35±3.5 min (n=20), compared to the afternoon hours (12 pm – 5 pm) - 18.81±6.81 min (n=26). The difference was significant ($P<0.05$, T-test result = 0.029). No significant difference was found between feeding frequency before and after mid-day.

Table 2. Feeding of the nestlings by adult saker falcons –frequency and time spent for a feeding event. Values given with confidence interval (for normal distribution).

Age of nestlings	The average interval of bringing food, Min	n	Average period for feeding of the nestlings (in the nest), Min	n
10–20 days	31.5 ± 9.59	17	13.94±4.11	18
20–30 days	55.3 ± 11.15	30	9.22±2.17	32
30–40 days	34.3 ± 16.59	22	16.42±6.92	26

Kleptoparasitism also was used as a feeding strategy by the saker - successful robbing of the prey was recorded from three species - marsh harrier (1 case), Montagu's harrier (*Circus pygargus*) (4 cases) and long-legged buzzard (4 cases).

Other birds also can grab prey from the sakers - for example, a raven successfully grabbed a souslik from an adult saker in Slivenska Mt.

Food

Adults of the reintroduced pair caught mainly sousliks. Very close to the nest there are some small colonies of these rodents. Additionally, some of the largest and densest colonies of sousliks in Bulgaria are situated in the neighboring Natura 2000 protected zones.

Among the prey of the sakers we registered voles (*Microtus arvalis*) and other small mammals. Furthermore, the sakers caught birds such as blackbirds (*Turdus merula*), starlings (*Sturnus vulgaris*), sparrows (*Passer hispaniolensis, Passer domesticus*), jackdaws (*Corvus monedula*), and rooks (*Corvus frugilegus*). Rarer prey items were red-backed shrike (*Lanius collurio*) and black-headed bunting (*Emberiza melanocephala*). By the last stage of the nesting period, the sakers started to bring also feral pigeons (*Columba livia var. domestica*) to the nest.

The abundance of food sources determined the high reproduction success of this saker pair.

The pairs from Slivenska Mt. were feeding mostly on sousliks and grey partridges (*Perdix perdix*) caught in the foothills of the mountain.

Reproductive behavior

Active mating flights – synchronous flights, cartwheeling, intensive vocalizations, bringing prey items by the male to the female as "gifts" and copulation were observed in February and the first half of March.

Incubation was done mainly by the female. The male replaced the female when she took off to hunt. In the last days before the hatching (15–30 April) the male brought food to the female in the nest.

The nestlings were fed by both parents. The male brought the prey, tore off pieces, and gave them to the nestlings in the same manner as the female. Always one of the birds was at a close distance from the nest. Only after 26–27 days of the nestlings' life the parents left them alone quite regularly. We have not observed cainism in any case even against smaller or ill nestlings.

The nestlings were capable of flying from the nest in the period 20–30 May, at an age of 42–45 days. The first flights were from a high place and the fledglings could not navigate the direction of the flight yet and were dependent on the wind. Usually, the biggest nestling fledged first, and the others fledged during the next 2–5 days. During the first week after leaving the nest, the young sakers improved their flight skills and successfully flew back to sleep or rest in the nest. Often the adults attracted

them by vocalization while bringing food into the nest. Nestlings of the sakers were observed regularly to collect invertebrates or small vertebrates (rodents) on the ground, in close vicinity of the nest.

After the disappearance of the female saker in 2021 (being found injured and delivered for rehabilitation), the male alone fed and took care of the three nestlings for a period of 19 days (16 April – 5 May), between 12 and 31 days of their life. On 5 May only two of the nestlings were still alive. On 7 May the remaining two nestlings were found dead under the nest. The male stopped feeding the nestlings after he found another female on 4 May and the nestlings jumped from the nest in an attempt to find food. Copulation of the new pair was observed on 4.5.2021.

After the death of the nestlings, the newly formed pair of sakers did not stay in the breeding territory anymore in that season.

The productivity and breeding success of the reintroduced saker pair were as follows:

- In the 2018 season – three nestlings hatched, and two were successfully reared until the fledgling stage.
- In the 2019 season – again three nestlings were hatched, and two were successfully reared.
- In the 2020 season (female replaced) – five nestlings were hatched, and four of them were successfully reared.
- In the 2021 season – three nestlings were hatched, and no offspring was successfully reared.

Discussion

Territorial defense and interspecific aggressive behavior in saker falcons has been discussed (Cramp and Simmons Eds 1980; Stoyanov and Kouzmanov 1998; Eakle et al. 2004) but without further analysis of the targets of the attacks. The aggression of neighboring breeding raptors, especially kestrels against the saker, reported in the present work, has been also observed in Western Bulgaria, Slovakia, and Czech Republik (Stoyanov and Kouzmanov 1998, Chavko et al. 2014; Skorpikova et al. 2017). According to the observations presented by us, it can be assumed that the young kestrels of one or two neighboring pairs were captured and eaten by the sakers. Such cases are reported also in Northern China (Ming et al. 2006).

Both partners of the saker pair took part in the nest defense but in the present study, it was found that during the period of incubation, this task was performed only by the male. Levels of aggression are expected to influence reproductive success and likely evolve under balancing selection (Anholt and Mackay 2012). Bolder animals have a higher chance for successful reproduction but a lower survival rate compared to shyer individuals of the same species (Schetini de Azevedo and Young 2021).

Real attacks of sakers from SE Bulgaria against a lesser spotted eagle and a marsh harrier were observed. Territorial conflicts between saker and marsh harrier were described also in Hungary (Eakle et al. 2004).

The male saker from the reintroduced pair stayed close and vocalized when a flock of Eleonora's falcons approached its territory. We have no information about published records of the relations between these two species.

In three cases sakers from Slivenska Mt. attacked peregrines. Taking into account the habitat characteristics, such cases can be territorial conflicts or a result of competition for breeding places. A similar case has been described by Stoyanov and Kouzmanov (1998).

Sakers from the mountains showed aggressive behavior much more often compared to the reintroduced birds. Behavioral traits can develop in quite a different way in captivity compared to the natural environment despite the efforts to avoid human presence close to the captive birds (McPhee and Carlstead 2010). Furthermore, aggressive behavior differs within the natural populations of a species (Brodkin et al. 2002) which can also be a reason for the detected discrepancy.

The nestlings were fed by both parents. According to a study made in Slovakia, the female is more active in feeding the nestlings compared to the male and two cases of feeding by both partners were reported (Chavko et al. 2014).

Nestlings of sakers were observed to regularly collect invertebrates or small vertebrates (rodents) on the ground, in close vicinity to the nest. Similar behavior but outside the breeding period has been reported for immature lanners (*Falco biarmicus*) feeding on termites on the ground in South Africa (Jensen 1972).

During the period, when the saker nestlings are 10–20 days old, the intensity of feeding is highest (Table 2), but the duration of separate feeding events is low. During this period the nestlings are fed with the smallest prey items (voles, mice, and passerines). Further when the nestlings grew up and developed, the feeding items became much bigger. A rapid increase in feeding frequency during the first three weeks of the life of the nestlings has been reported also for the kestrel (Wassink 2008) but afterward the frequency decreases (Rejt et al. 2000) as we show in the present work for the saker.

Kleptoparasitism of the saker was recorded against the following species in Serbia – *Falco tinnunculus* (70% of all cases), *Falco subbuteo, Corvus cornix, Corvus monedula, Circus aeruginosus, Circus cyaneus, Buteo buteo* and *Corvus corax* (Puzovic 2008). Kleptoparasitism of the Saker on marsh harrier, hen harrier and common buzzard was registered also in Austria and Hungary (Braun and Lederer 1996, Bagyura et al. 2003). The opposite kleptoparasitism was observed during the present study as a raven successfully grabbed a souslik from an adult saker. Similar cases of kleptoparasitism of some other raptors (*Aquila heliaca, Buteo buteo, Buteo lagopus, Accipiter gentilis, Haliaeetus albicilla*) on saker have been recorded in Slovakia (Chavko et al. 2019).

We have not observed cainism in any case, even against smaller or ill nestlings. In our opinion, this is a result of the sufficient amount of food brought by the adults

in the nest. Cainism (siblicide) is regularly observed in the nests of saker, peregrine, and gyrfalcon (*Falco rusticolis*) which are food-stressed (Leonardi 2020).

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The authors have declared that no competing interests exist.

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